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SOME EXPERIENCES WITH A CLASS OF REVIEWERS IN GEOMETRY.

BY SARA C. WALSH.

There was offered, at the Buffalo Central High School last January, a review geometry class in an attempt to aid, in a particular way, those who had failed in the regents' examination one or more times. On looking up the records of the applicants to the course, it was discovered that some had taken it two or more times and in one extreme case, the boy had registered ten terms. None of these pupils were mentally deficient, as was shown by exceptional work in other lines. Such remarks as these reached me at the first regular session of the class: "I'll *never* get it." "What's the good of it anyhow?" "I hate the stuff." "I'd like to get together all the geometry books in the school and watch them burn."

I made a few remarks somewhat as follows: "At my own request, this class was given to me because I am convinced that *anyone* can pass geometry who can do as creditable work in other lines as some of you can. There are in this class, to my knowledge, two excellent musicians and two with oratorical ability and these four people claim that they cannot do geometry. Perhaps it is great success in one line that discourages us at mediocre success in another. Should we give up because things are difficult? I think the reasons for a large share of failure in geometry are (1) that pupils do not try; (2) that a misconception creeps in or something is swallowed wholesale because the book says so or the teacher says so. You must work with me or I shall become discouraged and that would be the worst thing that could happen to you. I know that some of you are discouraged but this is an opportunity freely to discuss anything you want, without the feeling that some superior fellow student will glance condescendingly at you. You are all in the same boat. Will it move onward or sink?"

I racked my brain in a desire to make geometry resemble something entirely unfamiliar. We assumed a knowledge of

the definitions of angles, triangles, quadrilaterals, axioms with dozens of examples from common experience and the conditions under which triangles are congruent. So far, resignation was the reigning sentiment. We proved one or two simple exercises involving congruent triangles. Then I gave an exercise to prove triangles congruent and no one gave me the correct answer. One by one they seemed to come to the conclusion that there was no need of hesitation in this class. The guesses became wilder. We tried the same exercise three days before someone, in disgust, said he didn't think it could be done. This was the case. The hypothesis was not complete. I didn't tell them *that* but made them figure out why it couldn't be solved. If they wanted an angle equal to a certain angle, they said they were equal; either assigning no reason or giving a reason which did not agree with the facts granted. These triangles *had* to be proved congruent and evidently the end justified *any* means. Another kind of exercise which caused a mental upheaval was such as this: Are the diagonals of any parallelogram equal? Prove the truth of the conclusion. They could prove black was white if told to do so, but if they were *asked* if black was white they would debate the question and finally decide one way or the other. They tried from then on to use the hypothesis intelligently.

Gradually new propositions were added to those of the congruent triangles and were solved in class. A number of the class remembered the simpler proofs but if a question were put in the middle of their recitation they acted as if I had lost their place. One day, I asked why a certain construction line was used. One little girl volunteered this information: "That comes next." I repeated the question thinking she had misunderstood. She answered "I don't know." "All right, then continue the proof." She continued, giving a proof that sounded perfect, though she did not see what the construction line had to do with it. This and similar experiences showed me that often by happy chance or careful memorizing, but not because they belonged there, statement and authority were put side by side. In giving reasons, no shortened forms were allowed and corrections in recitations were encouraged. "How does the authority fit the statement" was one of the eternal questions on my part. Often

they did not know. During one recitation of a given book proof consisting of two parts independent of one another, followed by the conclusion, I started the proof, for the pupil who had been called on, and suddenly was interrupted by, "Pardon me but if you don't mind I would rather give *that* part second so I won't get my authorities mixed."

Every day we reviewed either all the authorities we were at liberty to use, or all theorems from a certain book, or all theorems ending with certain words as "The chords are equal." Sometimes I wrote on the board eight to ten or even twenty theorems and had them arranged in order, not by memory but according to the nature of their proof. From this they saw how the theorems were linked. For rapid work in showing the relation between book proofs, the most effective way I found was by drawing the figures in air. In doing this I used to have them answer in general terms or I would point out certain things and ask what they knew about them. It is a great help because it holds attention, strengthens imagination and permits of very rapid review of proofs. To test their attention, after they became familiar with this method, I used to point to certain things and say "These are equal why?" Sometimes, they were caught napping when the wrong thing had been pointed out. I discouraged their judging by inflection of my voice the probable answer. I used to lead them on to wrong conclusions to diminish this excessive dependence.

One of the most difficult things I have ever faced was to help these people to solve originals not depending on congruent triangles. Unless I helped, they decided they couldn't do them. If I did help, they memorized what I said. Many could not keep the goal in mind or would write a proof that was true so far as the hypothesis was concerned but did not fit the conclusion. I suggested working on rough paper as follows: make two columns. Label first "What I know." Label the second "What I want to know." Under the first were put the granted and all the conclusions that naturally came from it. Under the second were put the statement to be proved and the possible ways of solving it, that is all theorems that end with statement to be proved—the second last steps so to speak. It was of course a rather lengthy process but a sure one and the connec-

tion between the second step and one of the second last steps was usually within their power. This constant review of related theorems kept them in use and gradually this working out in rough became mental. A certain number of originals were due at a certain date. All above this number received extra credit. The pupils came to talk over mistakes so they could see *why* they were *wrong* as well as what was *right*.

Certain days we reviewed in class a group of exercises which had been solved as originals. Credit was given to the person finishing the proof. They were somewhat familiar with the proofs but of course had not memorized them. They could interrupt after due warning if the pupil reciting made any mistake in idea. They often noticed things which were really unimportant as leaving out an authority where it is implied. The retaliation was very amusing and everyone liked to share in it. Often the credit came to someone who did not have the courage to go through an entire proof but who did not hesitate to come in on the last statement. This mark of credit used to encourage greater effort next time.

In marking proofs in tests, I marked on Regents' basis. The students used more care when they saw how much they lost by omitting important authorities or by quoting so inaccurately as to change the sense or by omitting part of granted, etc.

There was in this class a youth who had been taking geometry for five years. He could play the piano, play football and make a good speech. He did well in English but the boys used to rail him about his extreme fondness for geometry. At the beginning of the term he came to me and said he believed he had never really worked in geometry but he was determined to get the examination this time. "Now how do you do this original?" he asked me. I had warned the class to be definite in their questions to know what was granted and what to be proved and write the proof as far as they could. So I said "What do you know?" With restrained wrath he exclaimed "If I knew I wouldn't have to ask." His idea of help was for me to say the whole proof off. At first he would say a line equalled a line "because I can see they are equal." He used to answer at random. Sometimes I asked him how much he would risk on the truth of his statements. Gradually he raised his estimate

of the truth of his statements. My chief conversation with him used to consist of these questions "What do you know? What do you want to know? Have you used everything granted?"

The morning of the examination I saw him in the hall. "Well what did you think of the examination?" I asked. He replied, "I kept saying to myself what do I know? what do I want to know until I was afraid I would find myself shouting it aloud. Another thing, I would stake my life that I got it this time." He received the highest mark in this class, 91. I sent him a card with his mark and my signature and within the next two days I saw him several times show that card to someone. *They had to be shown.*

Eighty-two per cent. of the class passed the Regents' examination and seemed pleased to have mastered at last that very difficult subject.

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